Addendum to the Final Report for Iowa Highway Research Board Project HR-253

EXPERIMENTAL USE of CALCIUM MAGNESIUM ACETATE

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Highway Division
Iowa Department of Transportation

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ADDENDUM TO FINAL REPORT
IOWA HIGHWAY RESEARCH BOARD
RESEARCH PROJECT HR-253

EXPERIMENTAL USE OF CALCIUM MAGNESIUM ACETATE

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INTRODUCTION

The Iowa Department of Transportation Materials Laboratory personnel developed a process to produce a road deicer consisting of sand grains coated with calcium magnesium acetate (CMA). Research project HR-253 was established to explore commercial production of the CMA/sand deicer by an independent contractor. About 60 tons of the deicer was produced at a ready-mix concrete facility and evaluated in the field during the 1983-1984 winter season.

The initial contracted production of CMA/sand deicer under research project HR-253 identified two major problems: (1) excessive unreacted lime in the final product, and (2) formation of spherical lumps within the product requiring subsequent size reduction. It was recommended in the HR-253 report that additional deicer be produced as a continuation of the project in order to address these problems and further develop the production process.

A contract was negotiated with W. G. Block Co. to produce and deliver 50 tons of additional deicer. This addendum report covers this production effort including descriptions and results of all modifications of equipment and process procedures used.

OBJECTIVES

The objectives of this work are:

A. To improve the deicing capabilities of the CMA/sand deicer product.

B. To further develop production equipment and procedures.

RAW MATERIAL AND MATERIAL HANDLING CHANGES

A. Acetic Acid

The glacial acetic acid was purchased in bulk and stored in one thousand gallon plastic tanks which replaced the handling and storage of the material in 55 gallon drums. The bulk acid was delivered at 80 deg. F. in a heated tank truck and transferred directly to the plastic tanks located in an isolated, heated building. The bulk acid cost about 7 cents per pound less than acid in drums which is a savings of about 23 percent.

Transfer of acid from the tanks for process use was through a hose and valve system that included a Halliburton meter. The meter controlled the pump operation so that a predetermined quantity of acid could be delivered to the mixing drum. It incorporated a solenoid signal to a pneumatic valve that shut off acid flow and admitted air to purge the delivery hose and acid spray lance system.

The automatic purging operation was a significant process improvement. After the lines were purged, the air was allowed to continue flowing through the lance into the reaction chamber. This removed water vapor formed by the reaction and contributed to the drying of the reaction product into a free-flowing, grannular material that was easily discharged from the mixer.

Handling the acid in this manner, within a closed system, was a successful, safer, and less labor intensive operation.

B. Hydrated Lime

Hydrated lime, produced by the pressure hydration process, was purchased from a new source expected to provide lime with a more reactive magnesium component. More reactivity was demonstrated in the laboratory by reacting the lime with a dilute acid solution. The new lime completely dissolved while a substantial amount of insoluble residue remained after reacting the lime used in the initial production.

The hydrated lime was obtained in bulk and stored in a large cement silo used in normal ready-mix concrete operations. This eliminated the labor intensive handling of lime in 50 pound bags.

Metering of bulk lime from a silo designed for handling Portland cement was not successful. Hydrated lime does not flow readily like cement and was therefore difficult to measure and transfer to the mixing truck. Self-compaction of the lime within the silo added to this difficulty.

Special equipment is needed to successfully store and to measure batch quantities of hydrated lime. This equipment would consist of a means to fluff the lime into a flowable material and a calibrated screw conveyor for measuring batch quantities by volume. Equipment intended for this purpose is available.

PROCESS EQUIPMENT CHANGES

A. Reaction Chamber Lining

The internal surfaces, including baffles, of the ready-mix truck drum were lined with 1/8-inch thick UHMW polyethyline sheeting attached by self-tapping metal screws. This lining replaced a graphite paint in an effort to obtain abrasion resistant, cling-free surfaces of longer life.

The lining performed as intended except a build-up of material occurred in the angle formed between drum surfaces and baffles. This build-up probably involved some mechanical bonding in the angled area and would be prevented by installing the sheeting to form curved corners. There was also a slight build-up of material on the back of the drum where mixing action is minimal.

B. Spray Lance Support Bearing

The bearing used to support the end of the acid spray lance was changed to a triple sealed bearing and the last two feet of spray jets on the lance were removed. These changes successfully eliminated binding of the lance end that occurred with an open support bearing.

C. Size Reduction Equipment

The vibrating 3/8-inch screen previously used to scalp oversized product as delivered was installed at the production site. Changes in procedures did reduce lump formation to 5 to 8 percent. It is apparent, however, that formation of some lumps in the final product is inevitable because of the rotating mixing action. Size reduction must therefore be made part of the production process.

PRODUCTION PROCEDURE CHANGES

A. Weather Conditions

Production was delayed until the outside ambient temperature was at least 60 deg. F., the weather was clear, and there was little or no wind. Previous experience had shown that colder temperatures caused rapid dissipation of heat needed to sustain the acid-lime reaction. The temperature during production varied from 60 to 75 deg. F. which was adequate for a controlled reaction.

The temperature limitation essentially limits production of deicer to a time between late spring and early fall. Production at other times of the year would require the mixing operation to be carried out in a heated enclosure.

B. Batch Sizes and Formulation

The deicer was produced with a CMA to sand ratio of 1 to 2 replacing the previous 1 to 1 ratio. The new ratio along with warmer outside temperatures made determination of the formulation quantity of lime to produce an alkaline product easier. A 2 percent excess of lime over the theorectical amount required to neutralize the acid was used.

The average bulk density of the 1:2 product is 78 pounds per cubic foot. This is about twice as heavy as the pure CMA produced for the Federal Highway Administration project.

Various batch sizes down to 2 tons were tried in an attempt to minimize lump formation. Loads smaller than 4 tons did not allow the drum to become hot enough for an effective reaction of lime and acid. There apparently is a critical thermal mass needed to develop the 140 deg. F. required.

The full batch charge of hydrated lime was transferred to the mixing drum before reaction with acid rather than holding out some lime for later addition. Holding out lime was not necessary to obtain full acid reaction.

The typical 4-ton batch used the following amounts of raw materials:

Acetic acid	225 gallons
Hydrated lime	1125 pounds
Concrete sand	5325 pounds
Grinding aid	65 milliliters*

*A solution of 300 ml of grinding aid in 3 gallons of water was dispensed onto the sand at a rate of 1 quart per minute as the sand was being conveyed at 1 ton per minute.

SUMMARY OF RESULTS

A. Production Yield

Eighty five thousand, two hundred pounds or 42.6 tons of 1:2 CMA/sand deicer was produced and delivered. Production was stopped when the supply of hydrated lime was depleted leaving an excess of about 220 gallons of acetic acid. The shortage of lime evidently resulted from inability to quantitatively transfer lime from the bulk delivery truck or from inaccurate measurement of batch weights from the cement silo.

B. Production Costs

Raw materials:

Acetic acid	$5508.50	
Hydrated lime	484.16	
Dried sand	111.83	$6104.49
Production and delivery		1876.14
	TOTAL COST	7980.63

Unit cost - $187.34 per ton

The above costs only reflect raw materials used and the negotiated price for production and delivery. They do not contain costs for equipment modifications, new equipment, and other research and development items. On this basis, the unit cost was lower than the prorated unit cost for 1:2 CMA/sand given in the HR-253 report. Cost of a 1:1, rock salt/sand mixture, is about $20 per ton.

C. Production Operations

The modifications of equipment and processes tried were all successful except for handling of bulk lime and eliminating the formation of lumps in the product during the reaction process. A flow sheet for the production process used is shown on the following page.

The use of ready-mix trucks to produce CMA/sand deicer is basic to the original concept of the project. As previously stated, formation of some lumps in the reaction product is inevitable because of the rotating mixing action. Since screening of any deicer product is likely to be necessary, the size reduction of the lumps is not considered a serious additional expense.

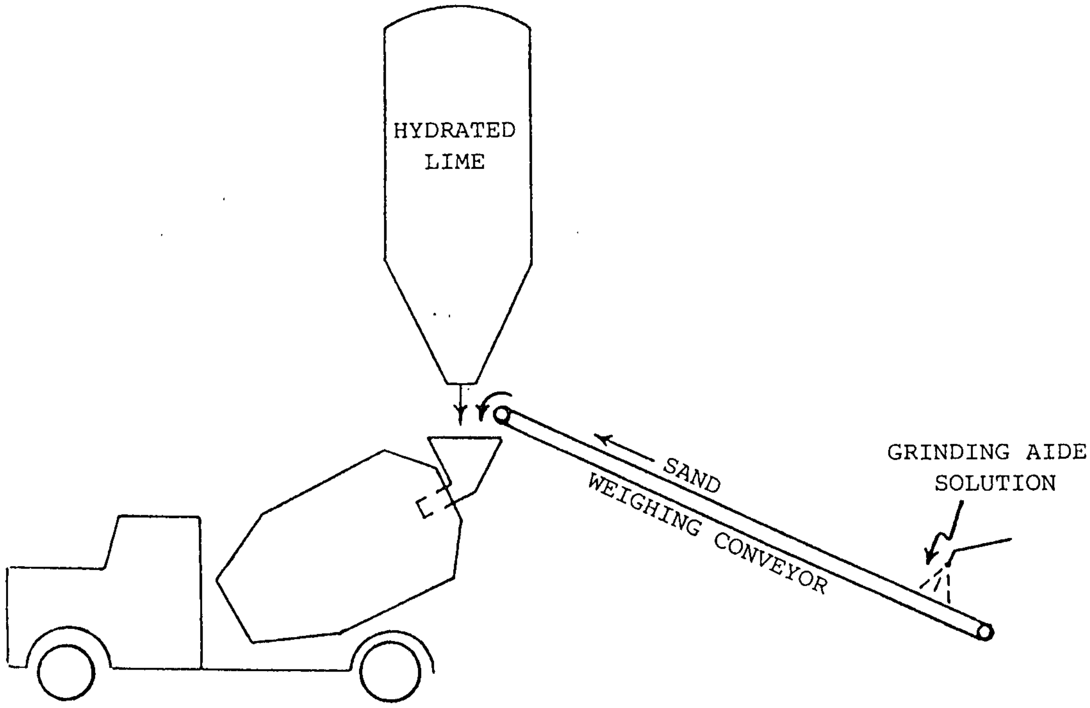
The final product resulting from this production effort is odorless and free of excessive unreacted lime. The problem with dust remains unresolved; however, the product is expected to show more effective deicing capabilities than that originally produced under project HR-253.

D. Production Capacity

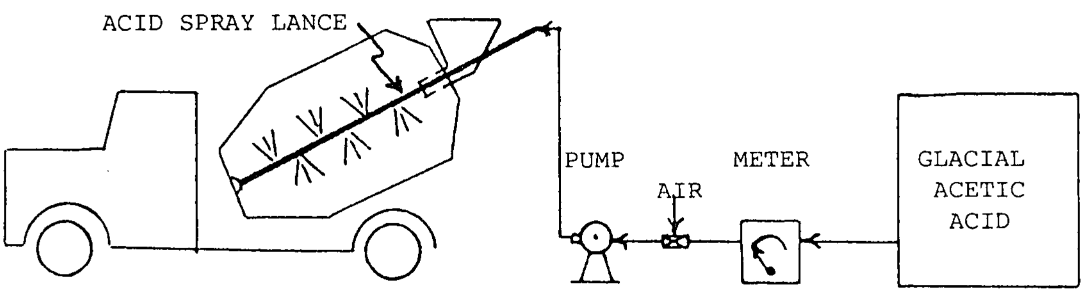
A minimum of 2 hours is required to produce a 4-ton batch using the current process. At a daily rate of 16 tons per truck, the batch process is only viable for very limited replacement of rock salt.

Large scale production equipment is being investigated for a continuous process that would produce 100 to 1000 tons per day. Possibilities include equipment used to produce asphalt paving mixtures or Portland cement.

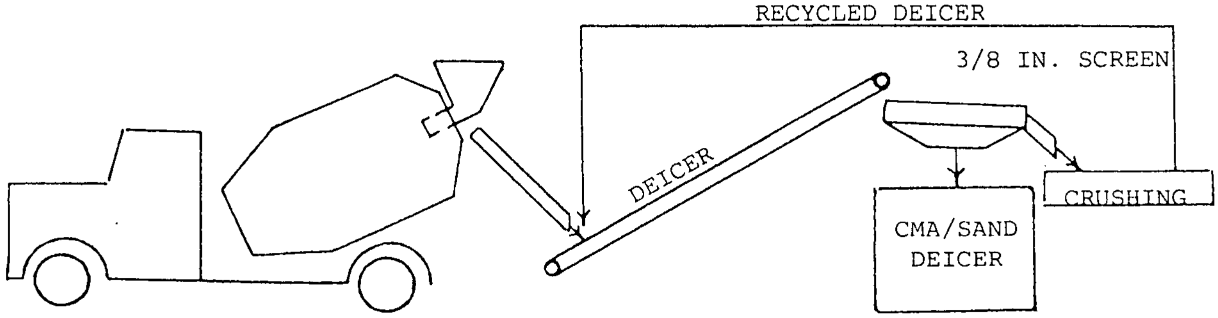
FLOW SHEET FOR CMA/SAND DEICER



STAGE 1 - LOADING SAND AND LIME



STAGE 2 - ACID TREATMENT AND REACTION



STAGE 3 - SIZING

CONCLUSIONS

With the exception of handling bulk hydrated lime, the procedural details of producing CMA/sand deicer with a CMA to sand ratio of 1 to 2 are adequately developed. Evaluation of the deicing capabilities of the final product will be made during the 1984-1985 winter season. Conclusions concerning the production process are:

1. Acetic acid should be purchased and handled in bulk quantities.
2. Special equipment is required to handle bulk hydrated lime.
3. Ultra-high molecular weight polyethyline sheeting is an adequate material for lining the internal surfaces of the ready-mix truck mixing drum.
4. Screening and size reduction of the final reaction product is a necessary process step.
5. Batch sizes must be at least 4 tons in order to maximize completion of the acid-lime reaction.
6. The outside ambient temperature must be at least 60 deg. F. or higher for the desirable open air operation.
7. Production of decier by this batch process is limited to 16 tons per day per truck.

RECOMMENDATIONS

It is recommended that further production of CMA/sand deicer be delayed until 1985. This will allow time to evaluate the 1:2 deicer in the field, to make decisions concerning the best way to handle hydrated lime, and to be assured of an adequate outside temperature during production.

An investigation of the possibilities of a continuous process capable of large scale production should be continued.